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NOAA Technical Report NMFS Circular 406

Marine Flora and Fauna of the Northeastern United States. Copepoda: Lernaeopodidae and Sphyriidae

Ju-Shey Ho

December 1977

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Ju-Shey Ho

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FOREWORD

This issue of the "Circulars" is part of a subseries entitled "Marine Flora and Fauna of the Northeastern United States." This subseries will consist of original, illustrated, modern manuals on the identification, classification, and general biology of the estuarine and coastal marine plants and animals of the northeastern United States. Manuals will be published at irregular intervals on as many taxa of the region as there are specialists available to collaborate in their preparation.

The manuals are an outgrowth of the widely used "Keys to Marine Invertebrates of the Woods Hole Region," edited by R. I. Smith, published in 1964, and produced under the auspices of the Systematics-Ecology Program, Marine Biological Laboratory, Woods Hole, Mass. Instead of revising the "Woods Hole Keys," the staff of the Systematics-Ecology Program decided to expand the geographic coverage and bathymetric range and produce the keys in an entirely new set of expanded publications.

The "Marine Flora and Fauna of the Northeastern United States" is being prepared in collaboration with systematic specialists in the United States and abroad. Each manual will be based primarily on recent and ongoing revisionary systematic research and a fresh examination of the plants and animals. Each major taxon, treated in a separate manual, will include an introduction, illustrated glossary, uniform originally illustrated keys, annotated checklist with information when available on distribution, habitat, life history, and related biology, references to the major literature of the group, and a systematic index.

These manuals are intended for use by biology students, biologists, biological oceanographers, informed laymen, and others wishing to identify coastal organisms for this region. In many instances the manuals will serve as a guide to additional information about the species or the group.

Geographic coverage of the "Marine Flora and Fauna of the Northeastern United States" is planned to include organisms from the headwaters of estuaries seaward to approximately the 200-m depth on the continental shelf from Maine to Virginia, but may vary somewhat with each major taxon and the interests of collaborators. Whenever possible representative specimens dealt with in the manuals will be deposited in the reference collections of major museums in the region.

After a sufficient number of manuals of related taxonomic groups have been published, the manuals will be revised, grouped, and issued as special volumes. These volumes will thus consist of compilations of individual manuals within phyla such as the Coelenterata, Arthropoda, and Mollusca, or of groups of phyla.

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Marine Flora and Fauna of the Northeastern United States. Copepoda: Lernaeopodidae and Sphyriidae

JU-SHEY HO[1]

ABSTRACT

This manual includes an introduction to the general biology, a glossary, an illustrated key, an annotated systematic list, a selected bibliography, and an index to the 16 species of lernaeopodoid Copepoda parasitic on marine fishes of the northeastern United States.

INTRODUCTION

The "Order Lernaeopodoidea" as defined by Yamaguti (1963) consists of four families of parasitic copepods. They are Lernaeopodidae, Chondracanthidae, Naobranchiidae, and Sphyriidae. However, Ho (1970) has presented evidence for removing from it the Chondracanthidae and Kabata (1969b) has added to it a new family, Tanypleuridae. Therefore, the "Order Lernaeopodoidea" as it now stands consists of four families: Lernaeopodidae, Naobranchiidae, Sphyriidae, and Tanypleuridae. Although there are doubts about the constitution of these four families of Copepoda as an Order, nevertheless, they form a coherent group and, for the sake of convenience, will be called "lernaeopodoid Copepoda" or "lernaeopodoids" throughout this subseries of the manual.

The lernaeopodoid Copepoda consists of some 300 species of extremely transformed copepods. They are all parasites of fish and known to fishermen as "gill maggots," due to their frequent occurrence on the gills of fish and the habit of wiggling their saclike bodies when irritated. Our knowledge of the biology of lernaeopodoids is particularly poor. Many species are vaguely known and have never been rediscovered or redescribed since their original description. A complete life history is known of some freshwater representatives (*Achtheres* and *Salmincola*) and only a few larval stages are known of the marine species. Information about their relationships with the host, to which they are permanently attached, is even more scanty.

The adult female of lernaeopodoids characteristically lacks copepod features, with a cylindrical cephalothorax attached to a baggy trunk and carrying no swimming legs. It attaches to the host either by burrowing into the flesh with its modified, elongate cephalothorax (Fig. 1), or by planting the bulla at the tip of its modified maxillae (Fig. 2) into the integument. The members of the family Naobranchiidae are different from other lernaeopodoids in fastening to their hosts by wrapping the modified beltlike maxillae around the gill filament. Adult female Lernaeopodidae and Naobranchiidae have their maxillae located posterior to the maxillipeds. According to Kabata and Cousens' (1973) study on the development of a freshwater lernaeopodid, this peculiar and unique transposition of appendages occurs during the later period of larval development. The lernaeopodoid larvae, copepodid and chalimus stages, are parasitic on the same host where the adults are found.

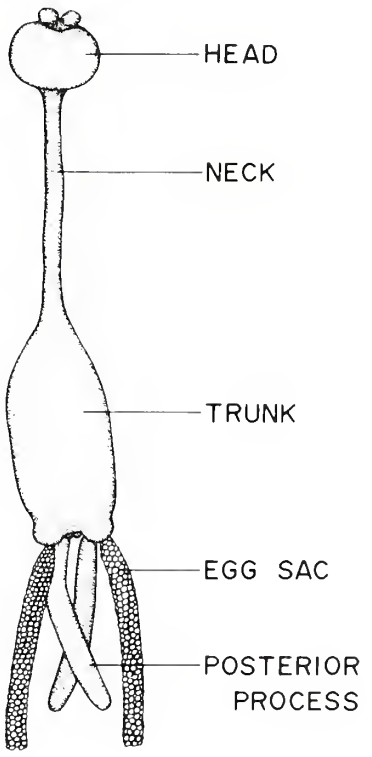

Figure 1.—*Paeon elongatus*; dorsal view, showing structures and terms used in key.

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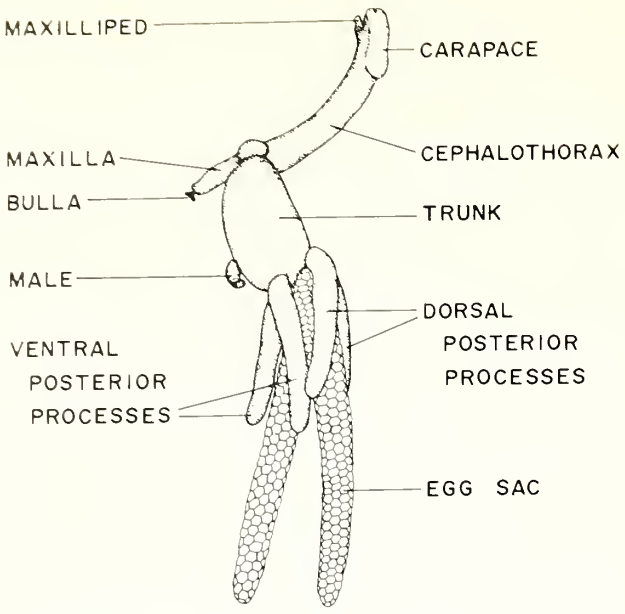

Figure 2.—*Brachiella gulosa*; lateral view, showing structures and terms used in key.

After the last molt in the chalimus stage, the adult female emerges and enters a period of metamorphosis and loses its copepod appearance.

The male is dwarf and frequently found attached to the female by means of its maxillae and maxillipeds. It lacks the locomotor appendages as in the female but no transposition of the maxillae occurs. After mating, the male either falls off the female and dies (thus, in many species only the female is known) or remains attached to the female for the rest of its life. It is not known whether the dwarf adult male feeds.

The appendages that are retained in the adult lernaeopodoids are the antennule, antenna, mandible, maxillule, maxilla, and maxillipeds. All of them, except the maxillae in Lernaeopodidae and Naobranchiidae, are crowded at the tip of the cephalothorax. In a few species of *Clavella*, however, vestiges of thoracic appendages other than the maxillipeds may be present. The mouth is located at the tip of the oral cone, which is comprised of a modified labium and a labrum. The tip of the mandibles are inserted into this oral cone. This arrangement of the mouth parts is also seen in the Caligoida and siphonostome Cyclopoida.

The family Lernaeopodidae is the largest of the lernaeopodoid Copepoda, containing about 260 species. However, only 12 species of this family are known to occur within the range covered by this manual (from Maine to Virginia). Although four species of Sphyriidae are presently known from this region, neither Naobranchiidae nor Tanypleuridae has been reported. Since only a fraction of fish species occurring off the coast of the northeastern United States have ever been examined for the copepod parasites, more species are yet to be reported.

The female lernaeopodoids damage their hosts by feeding on the tissue of the fins and gills and by injuring host tissues with the bullae and the anchorlike cephalothorax. Their burrowing cephalothorax sometimes perforates the abdominal wall and penetrates the visceral cavity. The sphyriids show some preference for attachment to the region of the dorsal aorta of the host, causing serious deleterious effects to the host.

In collecting specimens of lernaeopodoids, one must be very careful not to damage the burrowing or attaching part of the parasite, for, in many cases, this anchoring part of the parasite is of prime taxonomic importance (Kabata and Cousens 1972). If removal of the parasite must be done in the field without any optical aid, a generous amount of host tissue must be taken together with the parasite. The parasite is preferably preserved and stored in 70% alcohol. The study of its external anatomy sometimes requires dissection of the appendages. This is done first by soaking the specimen in lactic acid for several hours and then removing the appendages under the dissecting microscope with a pair of fine needles. These appendages should be mounted in a drop of lactic acid (80%) on a slide and then studied with a compound microscope. Staining of the appendages is generally not necessary. A special method for studying the copepod appendages devised by Humes and Gooding (1964) is highly recommended.

GLOSSARY

The lernaeopodoid copepods are so much transformed that some of their external features are quite different from a typical copepod. Therefore, certain terms which are not used in the anatomy of an ordinary copepod have been coined by investigators in working on this group of Copepoda. The following terms are used in this key to describe certain external features that are useful in identification. Some of them are illustrated in Figures 1 and 2.

antenna one of second pair of appendages that has fleshy appearance, with either one lobe (uniramous) or two lobes (biramous).

bulla a button-, cup-, or knoblike structure located at the terminal end of the maxillae. It is an attachment organ found in Lernaeopodidae.

carapace a dorsal shieldlike plate on the anterior end of the head.

cephalothorax a cylindrical, long structure representing the fused head and various parts of the thorax.

egg sac a sac or cylinder attached to the posterior end of the body and containing fertilized, developing eggs.

fimbriate process a cluster of fingerlike projections occurring either on the maxillae or at the posterior end of the body.

genital process a single protrusion located at the center of the posterior end of the body.

head anterior end of the body that bears the antennules, antennae, and the mouth parts. It is usually enlarged and/or covered with a carapace.

maxilla in Lernaeopodidae a modified, fleshy, armlike structure that holds the bulla. It is translocated to the posterior end of the cephalothorax in the course of development.

maxilliped one of sixth pair of appendages that is translocated in Lernaeopodidae and Naobranchiidae to the posterior end of head right behind the mouth or at a short distance from it.

neck a portion of transformed cephalothorax appearing long and slender.

posterior processes a pair of either simple or branched protrusions located at the posterior end of the body. They can originate either dorsal to the egg sacs (dorsal posterior processes) or ventral to the egg sacs (ventral posterior processes).

trunk a tremendously enlarged part of the body that represents the fused various parts of thorax and genital segment, with the vestigial abdomen identified by a slit (see Figs. 1, 8).

KEY TO THE MARINE LERNAEOPODOID COPEPODS OF THE NORTHEASTERN UNITED STATES

The following key is constructed for the 16 species of female sphyriids and lernaeopodids that have been reported parasitic on fishes from Maine to Virginia. A separate key to the male is not given because the dwarf male is characteristically attached to its female partner; an identification of the female will automatically lead to the identity of the male. Furthermore, some male lernaeopodoids do not show specific or even generic differences.

1	Attached to host by burrowing its modified anterior part of body (head and neck) (Fig. 1). Sphyriidae	2
1	Attached to host by means of bulla at the tip of modified maxillae (Fig. 2). Lernaeopodidae	5
2 (*1*)	Posterior processes simple cylinder (Fig. 1). Up to 35 mm	*Paeon elongatus*
2 (*1*)	Posterior processes profusely branched (Fig. 3B) or covered with short cylinders (Fig. 4B)	3

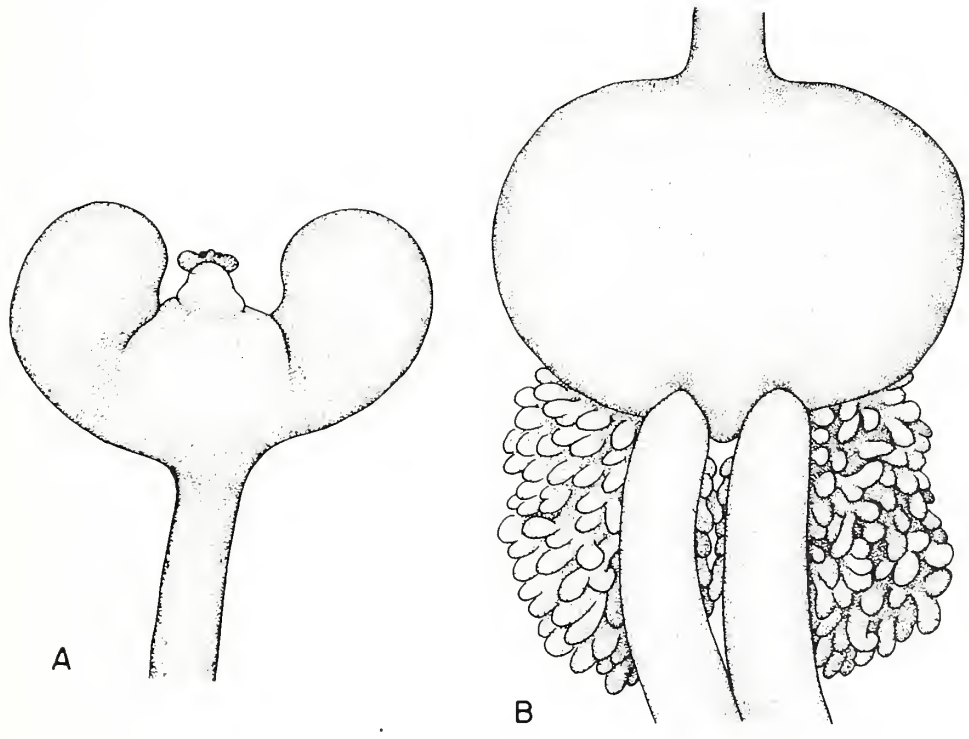

Figure 3.—*Sphyrion lumpi*; A, head and neck; B, trunk showing posterior processes.

3 (2) Head short and wide, with enormous lateral processes (Fig. 3A); posterior processes branched (Fig. 3B). Up to 60 mm . . . . . *Sphyrion lumpi*

3 (2) Head long and cylindrical; posterior processes covered with short cylinders (Fig. 4B) 4

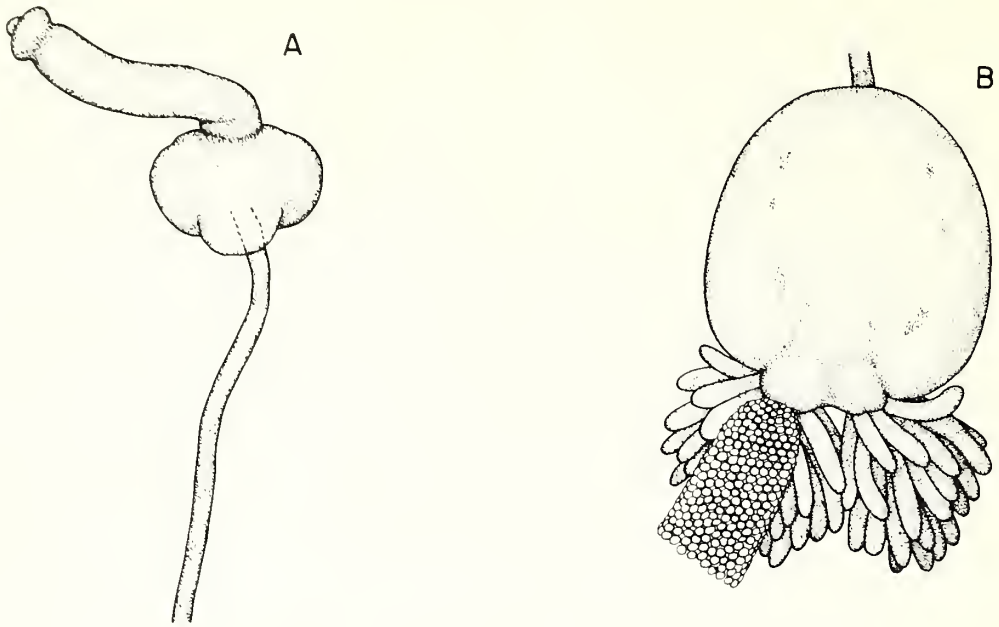

Figure 4.—*Lophoura bouvieri*; A, head and neck; B, trunk showing posterior processes.

4 (3) Head stout; anterior end of neck bearing spherical outgrowths (Fig. 4A). Up to 40 mm . . . *Lophoura bouvieri*

4 (3) Head slender; anterior end of neck bearing irregular processes (Fig. 5). Up to 55 mm . . . . . *Lophoura gracilis*

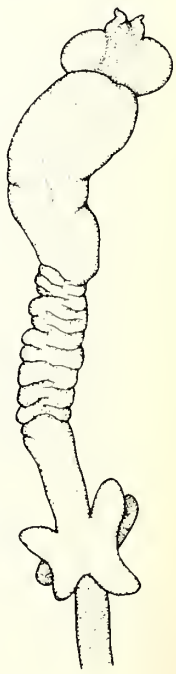

Figure 5.—*Lophoura gracilis*; head and neck.

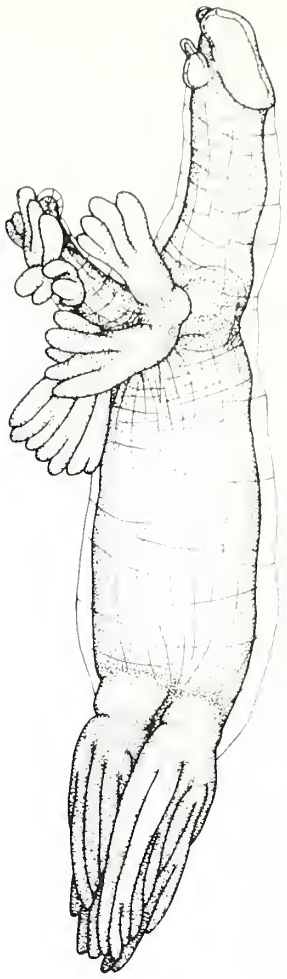

Figure 6.—*Thysanote pomacanthi*; lateral view.

5 (*1*) Trunk and maxillae with fimbriate processes (Fig. 6). Up to 8 mm . . . . . *Thysanote pomacanthi*

5 (*1*) No fimbriate processes on either trunk or maxillae 6

6 (*5*) Maxillae short, rudimentary, or lacking; posterior processes absent (Fig. 7A) 7

6 (*5*) Maxillae long; posterior processes present (Fig. 2) 11

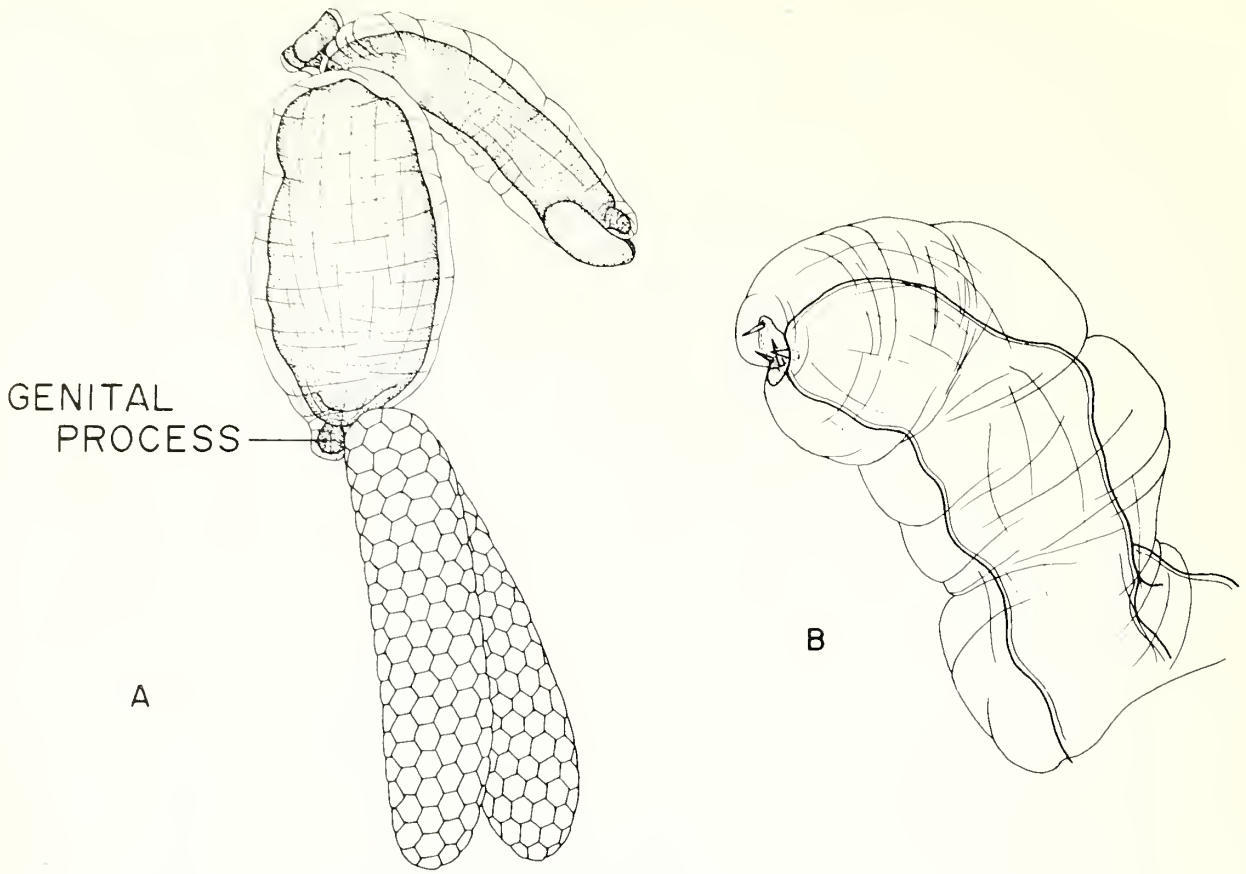

Figure 7.—*Clavella adunca*; A, lateral view; B, antenna.

7 (6) Antenna uniramous (Fig. 7B) 8

7 (6) Antenna biramous (Fig. 9B) 9

8 (7) Genital process present (Fig. 7A). Up to 4 mm . . . . . *Clavella adunca*

8 (7) Genital process absent (Fig. 8). Up to 6 mm . . . . . *Clavella insolita*

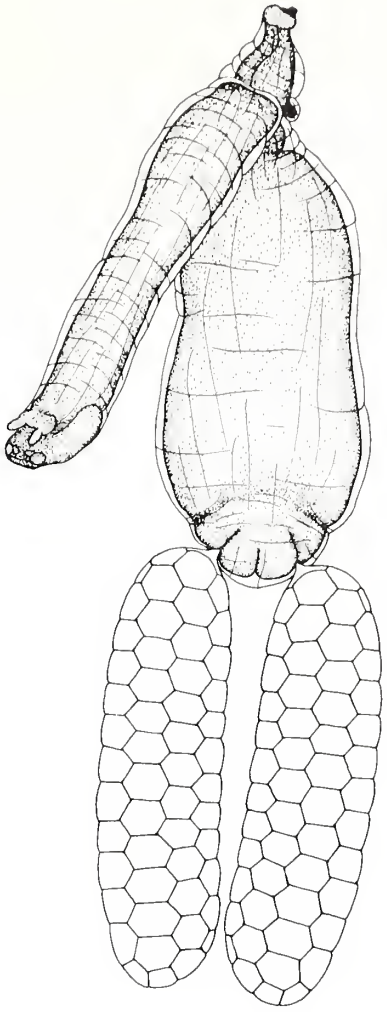

Figure 8.—*Clavella insolita*; dorsal view.

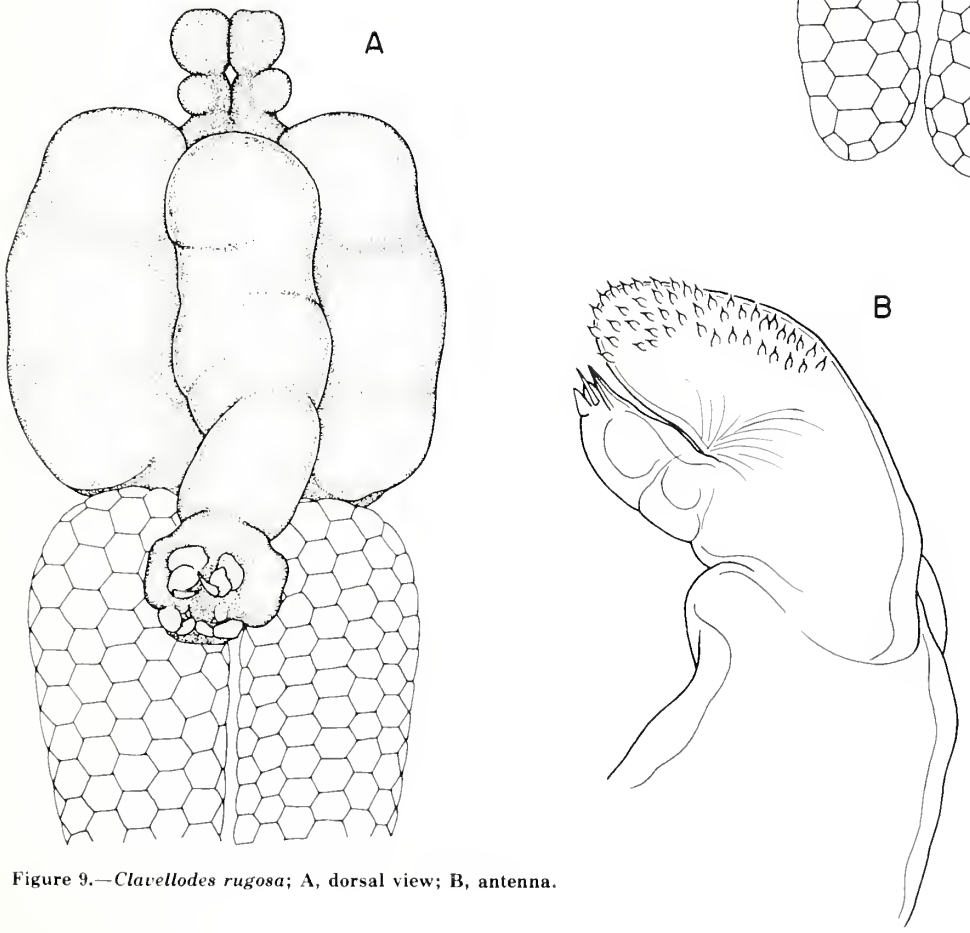

Figure 9.—*Clavellodes rugosa*; A, dorsal view; B, antenna.

9 (7) Cephalothorax attached to anterior end of trunk (Fig. 9A). Up to 5 mm . . . . . *Clavellodes rugosa*

9 (7) Cephalothorax attached to dorsal surface of trunk (Fig. 10) 10

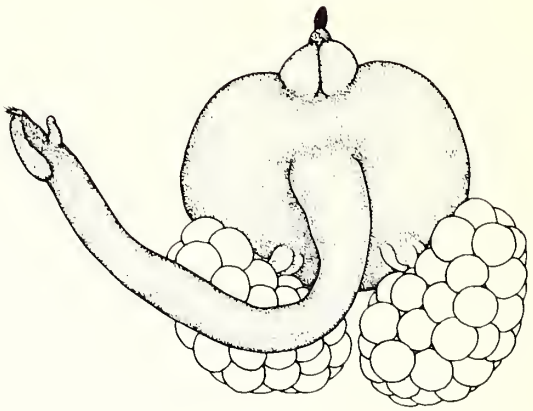

Figure 10.—*Clavellisa spinosa*; dorsal view.

10 (9) Egg sacs short, attached to trunk by one side and at an angle to body axis (Fig. 10). Up to 2 mm . . . . . *Clavellisa spinosa*

10 (9) Egg sacs long, attached to trunk by their ends and parallel with body axis (Fig. 11). Up to 4 mm . . . . . *Clavellisa cordata*

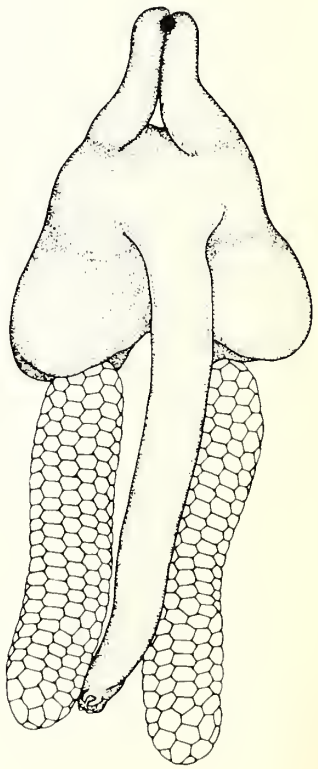

Figure 11.—*Clavellisa cordata*; dorsal view.

11 (*6*) One pair of posterior processes dorsal to egg sacs (Fig. 12); parasite of elasmobranchs 12

11 (*6*) One or two pairs of posterior processes; when one pair, always ventral to egg sacs (Fig. 14); parasite of teleosts 13

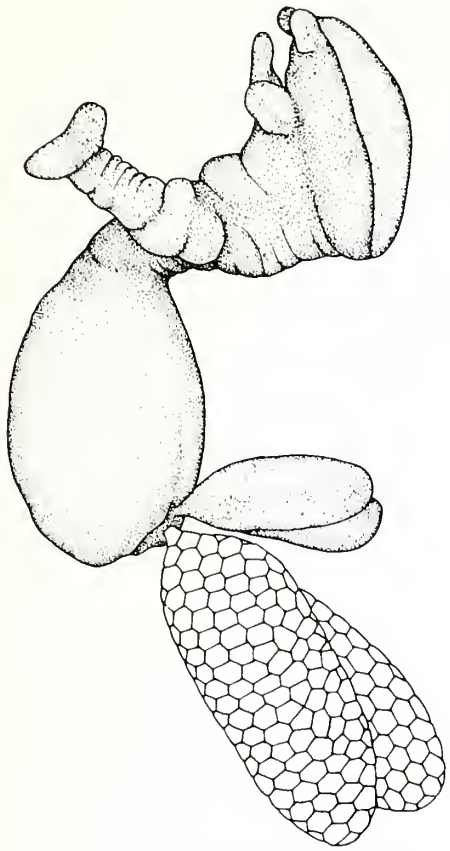

Figure 12.—*Pseudocharopinus bicaudatus*; lateral view.

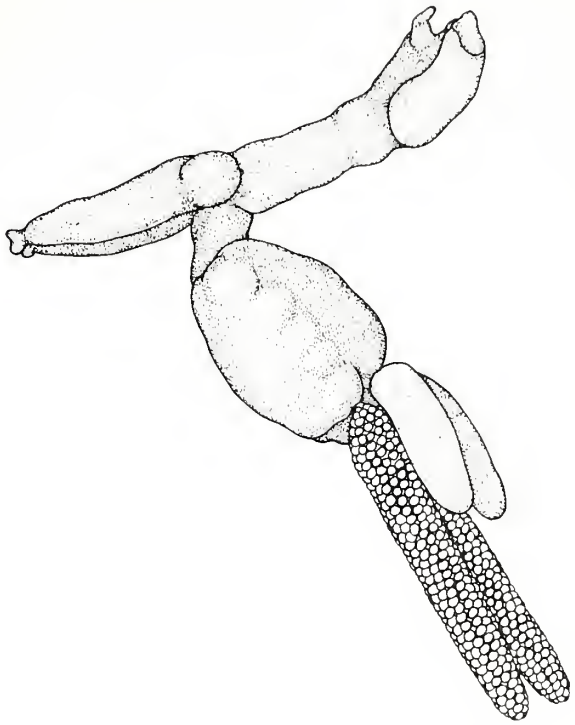

Figure 13.—*Pseudocharopinus concavus*; lateral view.

12 (*11*) Maxillae close to maxillipeds (Fig. 12). Up to 5 mm . . . . . .*Pseudocharopinus bicaudatus*

12 (*11*) Maxillae far away from maxillipeds (Fig. 13). Up to 7 mm . . . . . .*Pseudocharopinus concavus*

13 (*11*) One pair of posterior processes (Fig. 14) 14

13 (*11*) Two pairs of posterior processes (Fig. 2) 15

14 (*13*) Genital process extremely small; trunk distinctly longer than wide (Fig. 14). Up to 8 mm . . *Brachiella rostrata*

14 (*13*) Genital process large; trunk about as long as wide (Fig. 15). Up to 6 mm . . . . . *Brachiella mitrata*

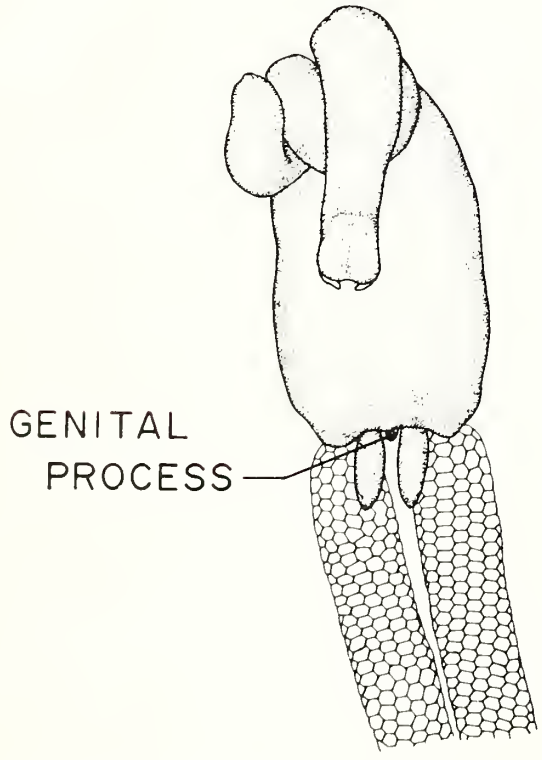

Figure 14.—*Brachiella rostrata*; ventral view.

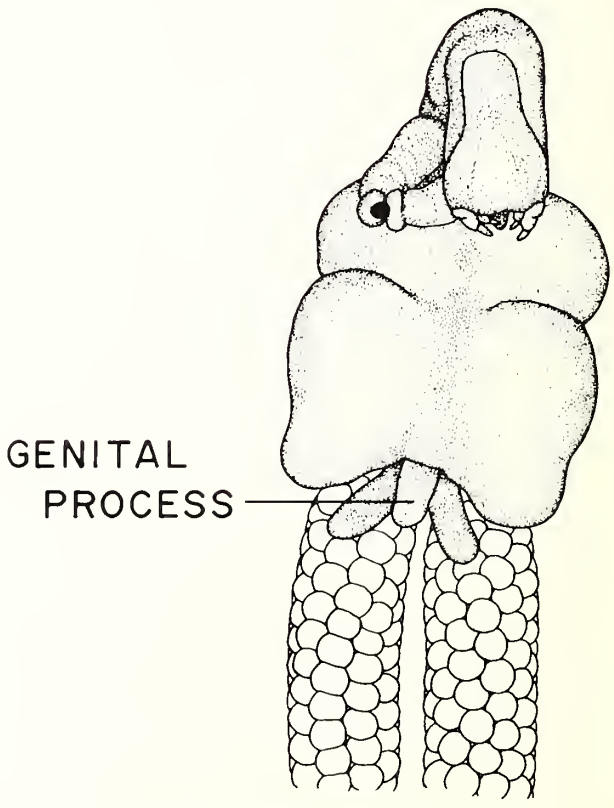

Figure 15.—*Brachiella mitrata*; ventral view.

15 (*13*) Ventral posterior processes slightly longer than dorsal; cephalothorax distinctly longer than trunk (Fig. 2). Up to 5 mm . . . . . .*Brachiella gulosa*

15 (*13*) Ventral posterior processes much longer than dorsal; cephalothorax about one-half of trunk (Fig. 16). Up to 10 mm . . . . . *Brachiella elegans*

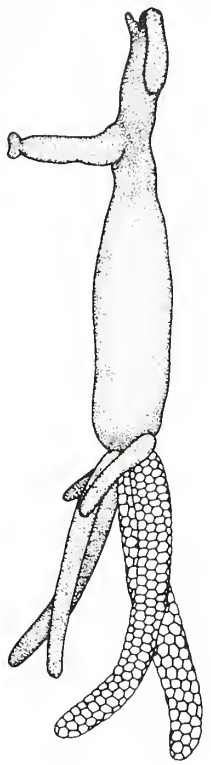

Figure 16.—*Brachiella elegans*; lateral view.

ANNOTATED SYSTEMATIC LIST

The following checklist of lernaeopodoid Copepoda is arranged alphabetically in families, genera under their family, and species under their genus. Notes on host and distribution are given. When more than one host is known, their names are arranged alphabetically in genera and species under their genus. If the common name of the host is known, it is given immediately preceding its scientific name. References to important works are cited.

Family LERNAEOPODIDAE

Brachiella elegans Richiardi 1880. On gills of leerfish, *Lichia amia*, in Mediterranean; greater amberjack, *Seriola dumerili*, from Woods Hole, Mass.; ghalanfish, *Trachinotus glauca*, in Mediterranean (Wilson 1915).

Brachiella gulosa Wilson 1915. Under operculum of red drum, *Sciaenops ocellatus*, New York to Texas (Wilson 1915).

Brachiella mitrata Wilson 1915. On gills of tilefish, *Lopholatilus chamaeleonticeps*, off Woods Hole, Mass. (Wilson 1915).

Brachiella rostrata Krøyer 1837. On gills of Atlantic halibut, *Hippoglossus hippoglossus*, in Kattegat, North Sea, Barents Sea, Greenland, and off Nantucket, Mass. (Wilson 1915).

Clavella adunca (Strom 1762). Synonym: *Clavella uncinata* (Müller 1776). On gills, buccal cavity, and fins of polar cod, *Boreogadus saida*, from Greenland; European dragonet, *Callionymus lyra*, from Britain; shargoush, *Diplodus sargus*, in Mediterranean; rudderfish, *Doydixodon fasciatum*, off Pacific coast of South America; Pacific cod, *Gadus macrocephalus*, in North Pacific off British Columbia, Alaska, Bering Islands, Hokkaido, and Okhotsk Sea; Atlantic cod, *G. morhua*, in North Atlantic off British Isles, Iceland, Greenland, Newfoundland, Nova Scotia, Maine, and Massachusetts; Greenland cod, *G. ogac*, from Greenland; *Gazza minuta* from Ceylon; greenling, *Hexagrammos octogrammus*, in Sea of Japan; Newfoundland eelpout, *Lycodes lavalaei*, off Nantucket, Mass.; *Macrurus fabricii* in Davis Strait; *M. whitsoni* off Antarctica; whiting, *Merlangius merlangus*, in North

Sea; European hake, *Merluccius merluccius*, in Adriatic Sea; Pacific tomcod, *Microgadus proximus*, off British Columbia; butterfish, *Pholis gunnellus*, in Mediterranean; *Pleurogrammus* sp. in Sea of Japan; pollack, *Pollachius pollachius*, in North Sea; pollack, *P. virens*, off Iceland and in Skagerrak; bass, *Sargus rondelti*, in Mediterranean; redfish, *Sebastes marinus*, from Davis Strait; Greenland shark, *Somniosus microcephalus*, off Iceland and Greenland; *Trematomus loennbergi* from east Antarctica; bib, *Trisopterus luscus*, in North Sea (Shiino 1956).

Clavella insolita Wilson 1915. Synonym: *Clavella pinguis* Wilson 1915. On fins of snake blenny, *Lumpenus lumpretaeformis*, off Rhode Island; Newfoundland eelpout, *Lycodes lavalaei*, in Barents Sea and off Nova Scotia and Nantucket, Mass.; Canadian eelpout, *L. polaris*, in Barents Sea; reticulated eelpout, *L. reticulatus*, from Nantucket, Mass., to Cape Hatteras, N.C.; *Macrurus* sp. off Nantucket, Mass. (Kabata 1969a).

Clavellisa cordata Wilson 1915. On gills and gill cavity of alewife, *Alosa pseudoharengus*, from Woods Hole, Mass.; American shad, *A. sapidissima*, from Woods Hole, Mass.; Atlantic herring, *Clupea harengus*, from Woods Hole, Mass. (Pillai 1962).

Clavellisa spinosa Wilson 1915. On gills of Atlantic menhaden, *Brevoortia tyrannus*, from Massachusetts to North Carolina (Wilson 1915).

Clavellodes rugosa (Krøyer 1837). On gills of northern wolffish, *Anarhichas denticulatus*, off Iceland and in Barents Sea; Atlantic wolffish, *A. lupus*, in North Atlantic off European coast, Iceland, Greenland, Newfoundland, Nova Scotia, and New England coast; spotted wolffish, *A. minor*, off Greenland (Kabata 1969a).

Pseudocharopinus bicaudatus (Krøyer 1837). On gills of common stingray, *Dasyatis pastinaca*, in North Sea; gray smoothhound, *Mustelus californicus*, from Pacific Grove, Calif.; smooth dogfish, *M. canis*, from Harpswell, Maine; eagle ray, *Myliobatis aquila*, from Mediterranean; *Rhinoptera marginata* from Mediterranean; spiny dogfish, *Squalus acanthias*, in North Sea, Barents Sea, Sea of Japan, and off coast of New England; piked dogfish, *S. fernandinus*, off Angola; *Trygon margarita* off Senegal; *T. marmorata* off Senegal (Kabata 1964).

Pseudocharopinus concavus (Wilson 1913). On gills of southern stingray, *Dasyatis americana*, off Texas; roughtail stingray, *D. centroura*, off Marthas Vineyard, Mass.; *D. hastata* from Jamaica; Atlantic stingray, *D. sabuna*, off Florida (Wilson 1913).

Thysanote pomacanthi Krøyer 1863. On gills of gray angelfish, *Pomacanthus arcuatus*, from Massachusetts to Florida, off Bahamas; French angelfish, *P. paru*, in West Indies.

Family SPHYRIIDAE

Lophoura bouvieri (Quidor 1912). Buried in trunk muscle of *Macrurus bairdii* off Marthas Vineyard, Mass., Block Island, and New Jersey (Wilson 1919).

Lophoura gracilis Wilson 1919. Buried in trunk muscle of *Histiobranchus bathybius* off New Jersey; *Synaphobranchus kaupi* off Marthas Vineyard, Mass.; an unidentified eel from Gulf of Mexico (Wilson 1919).

Paeon elongatus Wilson 1932. On gills of sandbar shark, *Carcharhinus milberti*, and dusky shark, *C. obscurus*, from Woods Hole, Mass. (Wilson 1932).

Sphyrion lumpi (Krøyer 1845). On trunk muscle of northern wolffish, *Anarhichas denticulatus*, in Barents Sea; Atlantic wolffish, *A. lupus*, in North Sea; *Antimora australis* off South Africa; blue hake, *A. rostrata*, off New Jersey; *Cottunculoides inermis* off South Africa; lumpfish, *Cyclopterus lumpus*, in North Sea and off Iceland; *Macrurus asper* off New Jersey; *Nematonurus goodei* off New Jersey; redfish, *Sebastes marinus*, off North Sea, Iceland, Greenland, Newfoundland, Nova Scotia, and from Maine to Massachusetts; deepwater rosefish, *S. mentella*, in North Sea (Wilson 1919).

SELECTED BIBLIOGRAPHY

HO, J.-S.
1970. Revision of the genera of the Chondracanthidae, a copepod family parasitic on marine fishes. Beaufortia 17:105-218.

HUMES, A. G., and R. U. GOODING.
1964. A method for studying the external anatomy of copepods. Crustaceana 6:238-240.

KABATA, Z.
1964. Revision of the genus *Charopinus* Krøyer, 1863 (Copepoda: Lernaeopodidiae). Vidensk. Medd. Dan. Naturhist. Foren. 127:85-112.
1969a. Four Lernaeopodidae (Copepoda) parasitic on fishes from Newfoundland and West Greenland. J. Fish. Res. Board Can. 26:311-324.
1969b. Tanypleuridae fam. nov. (Copepoda: Caligoida), parasitic on fishes in the Canadian Atlantic. J. Fish. Res. Board Can. 26:1407-1414.

KABATA, Z., and B. COUSENS.
1972. The structure of the attachment organ of Lernaeopodidae (Crustacea: Copepoda). J. Fish. Res. Board Can. 29:1015-1023.
1973. Life cycle of *Salmincola californiensis* (Dana 1852) (Copepoda: Lernaeopodidae). J. Fish. Res. Board Can. 30:881-903.

PILLAI, N. K.
1962. Copepods parasitic on South Indian fishes families Lernaeopodidae and Naobranchidae. J. Mar. Biol. Assoc. India 4:58-94.

SHIINO, S. M.
1956. Copepods parasitic on Japanese fishes. 12. Family Lernaeopodidae. Rep. Fac. Fish., Prefect. Univ. Mie 2:269-311.

WILSON, C. B.
1913. Crustacean parasites of West Indian fishes and land crabs, with descriptions of new genera and species. Proc. U.S. Natl. Mus. 44:189-277.
1915. North American parasitic copepods belonging to the Lernaeopodidae, with a revision of the entire family. Proc. U.S. Natl. Mus. 47:565-729.
1919. North American parasitic copepods belonging to the new family Sphyriidae. Proc. U.S. Natl. Mus. 55:549-604.
1932. The copepods of the Woods Hole region Massachusetts. U.S. Natl. Mus. Bull. 158, 635 p.

YAMAGUTI, S.
1963. Parasitic Copepoda and Branchiura of fishes. Interscience Publ., N.Y., 1104 p.

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The Board established the format for the "Marine Flora and Fauna of the Northeastern United States," invites systematists to collaborate in the preparation of manuals, reviews manuscripts, and advises the Scientific Editor of the National Marine Fisheries Service.

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COORDINATING EDITOR'S COMMENTS

Publication of the "Marine Flora and Fauna of the Northeastern United States" is most timely in view of the growing universal emphasis on environmental work and the urgent need for more precise and complete identification of coastal organisms than has been available. It is mandatory, wherever possible, that organisms be identified accurately to species. Accurate scientific names unlock the great quantities of biological information stored in libraries, obviate duplication of research already done, and often make possible prediction of attributes of organisms that have been inadequately studied.

Ju-Shey Ho began his study of the systematics of the parasitic Copepoda in 1960 when he was a teaching assistant at the Department of Zoology, National Taiwan University, Taipei, Taiwan. In 1962 he went to Boston University to pursue graduate studies on the copepod parasites of marine animals. Ho joined the faculty of California State University, Long Beach, in 1970 where he has continued his research on parasitic Copepoda. His studies have resulted in more than 50 papers on the systematics of marine parasitic copepods, including a monographic revision of Chondracanthidae at the generic level. Currently he is working on a series of copepod parasites from the fishes of the Great Barrier Reef, Australia.

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COULL, BRUCE C. Marine flora and fauna of the northeastern United States. Copepoda: Harpacticoida.
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388. Proceedings of the first U.S.-Japan meeting on aquaculture at Tokyo, Japan, October 18-19, 1971. William N. Shaw (editor). (18 papers, 14 authors.) February 1974, iii + 133 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

389. Marine flora and fauna of the northeastern United States. Crustacea: Decapoda. By Austin B. Williams. April 1974, iii + 50 p., 111 figs. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

390. Fishery publications, calendar year 1973: Lists and indexes. By Mary Ellen Engett and Lee C. Thorson. September 1974, iv + 14 p., 1 fig. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

391. Calanoid copepods of the genera *Spinocalanus* and *Mimocalanus* from the central Arctic Ocean, with a review of the Spinocalanidae. By David M. Damkaer. June 1975, x + 88 p., 225 figs., 4 tables. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

392. Fishery publications, calendar year 1974: Lists and indexes. By Lee C. Thorson and Mary Ellen Engett. June 1975, iv + 27 p., 1 fig.

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395. Report of a colloquium on larval fish mortality studies and their relation to fishery research, January 1975. By John R. Hunter. May 1976, iii + 5 p. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

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